NEW HANDBOOK OF MILITARY SIGNALING

HOWARD A. GIDDINGS

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PREPARED BY

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PREFACE

This book, first issued in 1896 under the title "Instructions in Military Signaling," has been revised at the urgent request of the publishers. The changes in codes and signaling systems have been so extensive that the handbook is in effect a new one.

The signal codes, conventional signals, letter codes, emergency signals, etc., are taken from the Signal Book, U. S. Army, 1916. These codes are public documents and cannot be copyrighted. The copyright upon this book relates only to its general arrangement and those portions not comprehended in public documents. The parts relating to the compass and its use and to map reading are a combination of matter in previous editions and recent articles by the author appearing in *Outing* magazine. They are necessarily elemental, and for further elaboration of details one of the several excel-

lent books upon topography, military sketching, map reading, etc., should be consulted.

HOWARD A. GIDDINGS,
Capt. U. S. Signal Corps (Vol.).

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The Signal Codes herein were approved and issued for the information and government of the military forces of the United States by order of the Secretary of War under date of April 15, 1916.

HANDBOOK OF MILITARY SIGNALING

CODES

THE AMERICAN MORSE CODE

1. The American Morse Code is used by the Army in the operation of land telegraph lines, short cables, and field telegraph lines. It is written as follows:

Alphabet

A	.—	L	——
B	—...	M	——
C	.. .	N	—.
D	—..	O	. .
E	.	P	.....
F	.—.	Q	..—.
G	——.	R	. ..
H	....	S	...
I	..	T	—
J	—.—.	U	..—
K	—.—	V	...—

W .——	Z ... .
X .—..	& . ...
Y	

Numerals

1 .——.	6 .....
2 ..—..	7 ——..
3 ...—.	8 —....
4 ....—	9 —..—
5 ———	0 ——

Punctuation

Period		..——..
Comma		.—.—
Interrogation		—..—.
Hyphen	(HX)	....—..
Dash	(DX)	—.. .—..
Parenthesis (begin)	(PN)	..... —.
Parenthesis (end)	(PY)	....
Quotation marks (begin)....	(QN)	..—.—.
Quotation marks (end).....	(QJ)	..—. —.—.
Dollar mark	(SX)	... .—..
Decimal point		Spell "dot."
Capitalized letter	(CX)	.... .—..
Brackets	(BX)	—... .—..

Colon .....(KO) —.— . .
Semicolon .....(SI) .... .
Underline (begin) .....(UX) ..— .—..
Underline (end) .....(UJ) ..— —.—.
Colon dash .....(KX) —.— .—..
Colon followed by quotation.(KQ) —.— ..—.
Exclamation point .....(!) ———.
Fraction bar .....(/) .
Paragraph mark .....(¶) ————
Pounds, sterling .....(£) (PX) ..... .—..
Shilling mark .....(UT) ..— —

Abbreviations

af .....after
ahr .....another
b .....be
bf .....before
bn .....been
ck .....check
cn .....can
da .....day
dl .....day letter
dpr .....day press rate
fm .....from
gn .....good-night

govt ..... government
hr ..... hear or here
hv ..... have
msg ..... message
nite ..... night
nl ..... night letter
npr ..... night press rate
ob ..... official business
pd ..... paid
r ..... are
t ..... the
u ..... you
ur ..... your
w ..... with
wrd ..... word
x (in check) ..... get a reply to this message
5 ..... Have you anything for me?
13 ..... understand

CONVENTIONAL SIGNALS FOR USE WITH THE AMERICAN MORSE CODE

2. The following conventional signals are used on military telegraph lines, short cables, and field lines:

Attention, all operators.....(9) —..—
Please start me (or) where
shall I start.....(4) ....—
Wait a moment.....(MIN) ——.. —.
Official message .....(OFM) . . .—. ——
I understand .....(OK) . . —.—
Busy on other wires.....(25) ..—.. ————
No more .....(NM) —. ——
Test, give away.....(WIRE) .—— . . . . .
Break .....(BK) —... —.—
Go ahead .....(GA) ——. .—
Error .....(DN) —.. —.
Signature follows .....(SIG) ..... ——.

TRANSMISSION OF FIELD MESSAGES BY AMERICAN MORSE

3. The sending operator will enter the time *when the message is handed him for transmission*, in the left-hand corner at the bottom of the blank opposite the word "Received." He will enter in the proper places, at the head of the blank, the number of the message, the call letter of his station, with his personal signal, the check (number of words or groups of cipher

contained in message, *counting address and signature*), and after "O. K." has been received he will enter the time the message was sent and the call letter of the receiving station, with the personal signal of the receiving operator.

4. To transmit a message the operator will send (1) the number of the message and call letter of his station; (2) his personal signal; (3) the check; (4) "fm," followed by the name of the sending detachment; (5) "at," followed by the location of the sending detachment and date; (6) "ho," followed by the hour (a. m. or p. m.) message was written; "No." (Sender's serial number); (7) "to," followed by the address in full; (8) period (..——..); (9) body or text of the message; (10) "sig," followed by the signature of the message.

THE INTERNATIONAL MORSE OR GENERAL SERVICE CODE

5. The International Morse Code is the General Service Code and is prescribed for use by the Armies of the United States and between the Armies and the Navy of the United States. It is used on radio systems, submarine cables using siphon recorders, and with the heliograph, flash-lantern and all visual signaling apparatus using the wig-wag.

Alphabet

A	.—	K	—.—
B	—...	L	.—..
C	—.—.	M	——
D	—..	N	—.
E	.	O	———
F	..—.	P	.——.
G	——.	Q	——.—
H	....	R	.—.
I	..	S	...
J	.———	T	—

U	..—	X	—..—
V	...—	Y	—.——
W	.——	Z	——..

Numerals

1	.—————	6	—....
2	..————	7	——...
3	...——	8	———..
4	....—	9	————.
5	.....	0	—————

Punctuation

Period	.....
Comma	.—.—.—
Interrogation	..——..
Hyphen or dash	—....—
Parenthesis (before and after the words)	—.——.—
Quotation mark (beginning and ending)	.—..—.
Exclamation	——..——
Apostrophe	.————.
Semicolon	—.—.—.
Colon	———...
Bar indicating fraction	—..—.

Underline (before and after the word or words it is wished to underline) ....——.—

Double dash (between preamble and address, between address and body of message, between body of message and signature, and immediately before a fraction) ..... —...—

Cross ..... .—.—.

CONVENTIONAL SIGNALS FOR USE BY RADIO STATIONS WITH THE INTERNATIONAL MORSE CODE

6. The following conventional signals will be used by radio stations of the United States Armies with the International Morse Code:

Distress signal (ship stations only) ...———...

Attention (or call)..The call is composed of the attention signal —.—.— followed by the call letters of the station called, repeated three times [if unknown

use CQ (—.—. ———. —) in place of call letters of station called], followed by DE (—.. .) and then the call letters of the calling station, repeated three times.

Have you anything for me .....QRU (——.— .—. ..—)

How many words have you to send..QRJ (— — . — . — . . — — —)

Invitation to transmit (go ahead) —.—

Signal separating preamble from address, address from text, and text from signature..... —...—

End of message... .—.—.

End of work..... ...—.— followed by the call letter of sending station and —.—

Received (acknowledgment of receipt of message) .....R (.—.), followed by the call letter of the receiving station and personal signal of the receiving operator.

Here is another message..... —.—.— (attention call).

Understood (or I understand)..... ...—. followed by the call letters of station.

Not understood (or repeat) ....———.. (Interrogatory) and the last word received.

Error ....

Wait ..... .— ...

Official message ....OFM (— — — . . — . — —)

(First word of preamble on all radiograms) .....RADIO (.—. .— —.. .. — — —)

Faster .....QRQ (— — . — . — . — — . —)
Slower .....QRS (— — . — . — . . .)
Stop sending .....QRT (— — . — . — . —)
Interference .....XX (— . . — — . . —)
Use International Code of Signals...PRB(. — — . . — . — . . .)
General inquiry call (when call of station is not known). CQ (— . — . — — . —) (see attention call).
How do you receive me .....QRK (— — . — . — . — . —)

TRANSMISSION OF MESSAGES BY INTERNATIONAL MORSE CODE

EXAMPLE

WVB sending to WVA a plain commercial message filed at 4 p. m., of the 12th, after receiving — . — — . — . —

RADIO
Circle City .....Office of destination.

De.
Fairbanks .....Office of origin.
2 .....Number of message.
L .....Operator's sign.
8 .....Check.
Twelfth 4 pm.....Date and hour of filing.
—...— .....Break or double dash.
Brown 175 King Street
Circle City .....Address.
—...— .....Break.
Arrive tomorrow .....Text.
—...—.....Break.
Jones .....Signature.
.—.—.
KMO
—.—

VISUAL SIGNALING IN GENERAL

7. Methods of visual signaling treated herein are divided as follows:

(*a*) By flag, torch, hand lantern, or beam of searchlight (without shutter). (General Service Code.)

(*b*) By heliograph, flash lantern, or searchlight (with shutter). (General Service Code.)

(*c*) By Ardois. (General Service Code.)

(*d*) By hand flags. (Two-arm semaphore Code.)

8. The following conventional signals, with exceptions noted, will be used.

		Exceptions
End of word.	Interval.	Ardois.
End of sentence.	Double interval.	
End of message.	Triple interval.	
Signal separating preamble from address; address from text; text from signature.	— • • • —	Double interval, signature preceded also by "Sig." interval.

Acknowledgment.	R.	
Error.	. . . . .	A.
Negative.	K.	
Preparatory.	L.	
Annuling.	N.	
Affirmative.	P.	
Interrogatory.	. . — — . .	O.
Repeat after word.	Interrogatory, A (word).	
Repeat last message.	Interrogatory three times.	
Send faster.	QRQ	
Send slower.	QRS	
Cease sending.	QRT	
Wait a moment.	. — . . .	None.
Execute.	IX, IX.	
Move to your right.	MR	
Move to your left.	ML	
Move up.	MU	
Move down.	MD	
Finished (end of work).	. . . — . —	None.

9. *Note.*—In order to differentiate these signals from important battle signals, the Navy uses certain distinguishing variations which are not necessary in signaling in the Army. In making the conventional signals for "A," Error, and "O," Interrogatory, in Ardois, the Navy indicates them by pulsating the upper light; in

making them in semaphore, by agitating the arms or flags. "K," Negative; "L," Preparatory; "N," Annuling; "O," Interrogatory; and "P," Affirmative, in the Navy are secondary meanings, and are used only in connection with Navy Code Books. They should not be used in communication between Army and Navy.

In communicating with the Navy, by all methods, numerals will be spelled out.

10. "Intervals" are expressed as follows in the various systems:

	Interval.	Double interval.	Triple interval.
Radio. Flashing. Occulting light. Sound.	— space.	. . . . .	. — . — .
Wigwag.	Front.	(Twice.)	(3 times.)
Hand flags.	Flags crossed.	2 chops.	3 chops, withdraw flags.
Ardois.	. — . —	(Twice.)	(3 times.)

GENERAL INSTRUCTIONS FOR ARMY SIGNALING

11. Each signal station will have its call, consisting of one or two letters; as Washington, "W"; and each operator or signalist will also have his personal signal of one or two letters, as Jones, "Jo." These being once adopted will not be changed without due authority.

To lessen liability of error, numerals which occur in the body of a message should be spelled out.

In receiving a message the man at the telescope should call out each letter as received, and not wait for the completion of a word.

A record of the date and time of the receipt or transmission of every message must be kept.

The duplicate manuscript of messages received at, or the original sent from, a station should be carefully filed.

In receiving messages nothing should be taken for granted, and nothing considered as seen until it has been positively and clearly in view. Do

not anticipate what will follow from signals already given. Watch the communicating station until the last signals are made, and be very certain that the signal for the end of the message has been given.

Every address must contain at least two words and should be sufficient to secure delivery.

All that the sender writes for transmission after the word "To" is counted.

Whenever more than one signature is attached to a message count all initials and names as a part of the message.

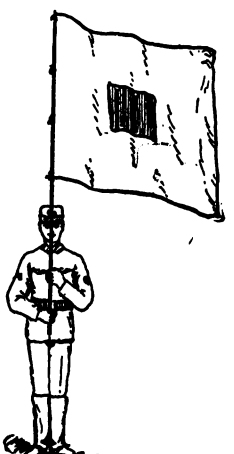
ORDER OF SENDING A MESSAGE

12. 1—Number of message.
2—Place from, and date.
3—Address in full.
4—Body of message.
5—Sig (signature follows).
6—Signature.

VISUAL SIGNALING: BY FLAG, TORCH, HAND LANTERN, OR BEAM OF SEARCHLIGHT (WITHOUT SHUTTER)

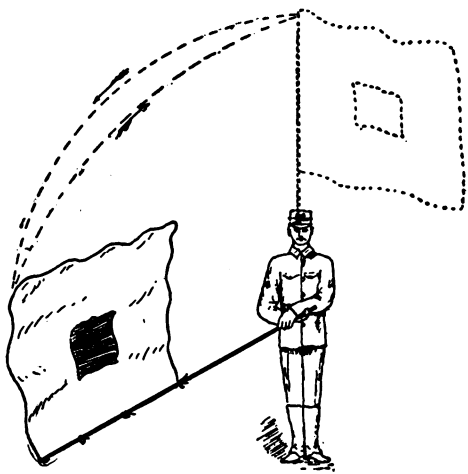
GENERAL SERVICE CODE

13. For the flag used with the General Service Code there are three motions and one posi-



Position

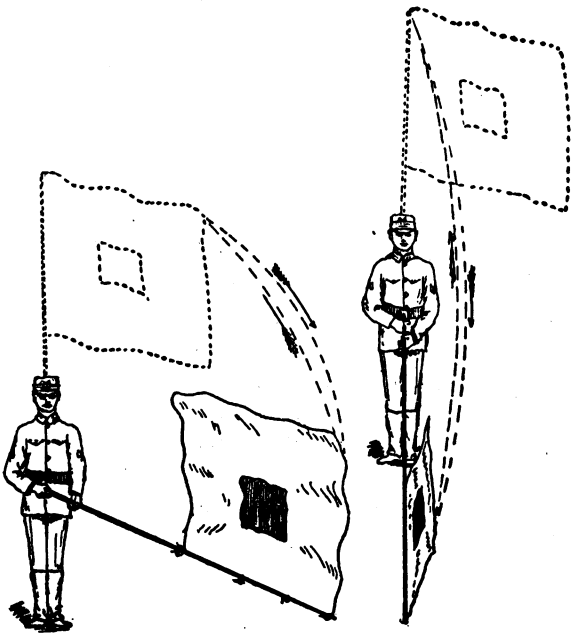
tion. The position is with the flag held vertically, the signalman facing directly toward the station with which it is desired to communicate.



Dot

The first motion (the dot) is to the right of the sender, and will embrace an arc of 90°, starting with the vertical and returning to it, and will

be made in a plane at right angles to the line connecting the two stations. The second motion



Dash Front

(the dash) is a similar motion to the left of the sender. The third motion (front) is downward directly in front of the sender and instantly returned upward to the first position. Front is used to indicate an interval.

14. The beam of the searchlight, though ordinarily used with the shutter like the heliograph, may be used for long-distance signaling, when no shutter is suitable or available, in a similar manner to the flag or torch, the first position being a vertical one. A movement of the beam 90° to the right of the sender indicates a dot, a similar movement to the left indicates a dash; the beam is lowered vertically for front.

To use the torch or hand lantern, a footlight must be employed as a point of reference to the motion. The lantern is most conveniently swung out upward to the right of the footlight for a dot, to the left for a dash, and raised vertically for front.

SIGNALING WITH HELIOGRAPH, FLASH LANTERN, OR SEARCHLIGHT (WITH SHUTTER)

GENERAL SERVICE CODE

15. The first position is to turn a steady flash on the receiving station. The signals are made by short and long flashes. Use a short flash for dot and a long steady flash for dash. The elements of a letter should be slightly longer than in sound signals.

To call a station make its call letter until acknowledged.

If the call letter of a station be unknown, signal A until acknowledged. Each station will then turn on a steady flash and adjust. When the adjustment is satisfactory to the called station, it will cut off its flash, and the calling station will proceed with its message.

16. If the receiver sees that the sender's mirror or light needs adjustment, he will turn on a steady flash until answered by a steady flash.

When the adjustment is satisfactory, the receiver will cut off his flash and the sender will resume his message.

To break the sending station for other purposes, turn on a steady flash.

It may be noted that in the daytime and in ordinary weather the searchlight with shutter can be readily used for distances up to 10 miles at sea. This method of day signaling is considered of exceptional value by the Navy, and is commonly used by the Coast Artillery in target practice from the shore to the tug towing the target. It is independent of background and may be used behind armor or other shelter; it should be frequently used for signaling by day as well as by night.

THE FLAG

17. Signal flags are made of muslin or other material of light and close texture, are square in shape, and have a smaller square in the center, comprising one-ninth of the surface of the flag, of a different color from the body of the flag.

Those commonly used are: The white flag, four feet square, having a red block sixteen inches square in its center. The red flag, four feet square, having a white block sixteen inches square in its center. The white flag, two feet square, having a red block eight inches square in its center. The red flag, two feet square, having a white block eight inches square in its center.

In addition to the above, six-foot flags with centers two feet square are often used, and black flags with white centers are sometimes the most suitable, as in case of sky backgrounds.

All flags are fitted with tapes on one edge,

one foot apart, for tying them to the staff. The staff is in two, three, or four joints, each four feet in length. Two or three joints are ordinarily used, but the longer the distance the larger the flag and longer the staff.

SIGNALING WITH THE FLAG

18. The signalman is first instructed in the use of the two-foot flag, on the upper joint. He takes the position of the soldier, faces exactly toward the receiving station, with the staff vertical in front of the center of his body, holding it with either hand at the butt, which should be at the height of the waist.

An imaginary line, from a point between the feet of the sender to the receiver, is called the *line of vision.*

In swinging the flag, each motion to the right or left should be exactly at right angles to the line of vision, and each front motion should be in the line of vision. To insure this, stakes may be driven in the line of vision a short distance in front of the flagman and at right angles to it, the same distance to the right and left. The

staff should point in the direction of one of these stakes at each wave.

Expert signalmen will not need the stakes for day signaling.

The instructor should explain to the recruit how to keep the flag open and prevent its fouling with the staff, by giving the end of the staff a slight *scoop* as it reaches the lowest point in its motion.

The scoop should be made against the wind.

The importance of clean, clear cut motions of the flag in a plane exactly at right angles to the line of vision cannot be overestimated.

The staff should be kept as upright as possible, and the flag kept open, as when fouled on the staff it may become quite invisible during several motions.

In a clear atmosphere the four-foot flag may be read with the naked eye four or five miles; with a field glass or telescope about twice as far.

19. *Powers and limitations of flag signaling.* —The advantages which may be claimed for this method of signaling are portability of apparatus, adaptability to varied weather conditions,

and great rapidity of station establishment. The disadvantages are the lack of celerity of the signals, their impenetrability to dust or smoke, and the comparatively short ranges at which they can be read. These ranges vary with the background, light, vision, and power of glasses if used.

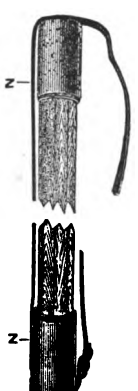
20. *Care of flag material.*—Signal flags should be examined at the close of drill or use and repairs made to any rents or loose ties discovered. Flags, when soiled, should be thoroughly washed and dried in the sun. Signals made by clean flags are much more easily read than those made by dirty ones. Staffs should be handled with care, especially when jointing or unjointing. Care should be taken not to bruise the ends of the brass ferrules. Ferrules fitting together so loosely as to permit separation of the joints in signaling must not be hammered or jammed, but should be tightened by wrapping one or more thicknesses of thin paper around the one which is inserted in the other. If a ferrule becomes loose on a staff it should be tightened without delay.

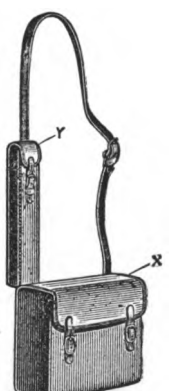
THE HELIOGRAPH

21. The field heliograph equipment consists of—

x. A sole-leather pouch, containing:

One sun mirror.
One station mirror. } Inclosed in a wooden box.
One shutter. One sighting rod. One screw-driver.





Y. A smaller pouch, sliding by two loops upon the strap of the larger, containing one mirror bar.

Z. A skeleton case, of leather, containing two tripod stands.

C. Sun mirror.

D. Station mirror.

E. Mirror supports.

F. Tangent screws for revolving mirror about horizontal axis.

G. Mirror bar.

H. Tangent screw with ball bearings for revolving mirror about vertical axis.

I. Clamp screw for attaching mirror bar to tripod.

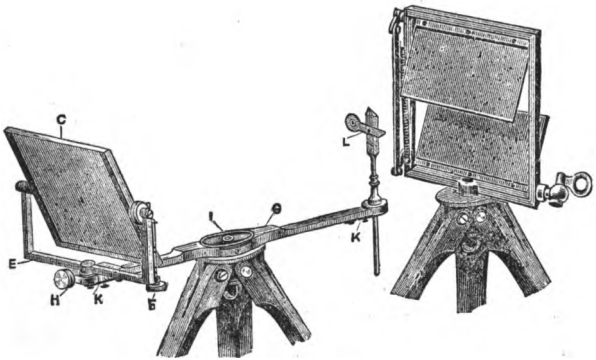
K. Spring for clamping mirrors and sighting rod.

L. Sighting rod with movable disk.

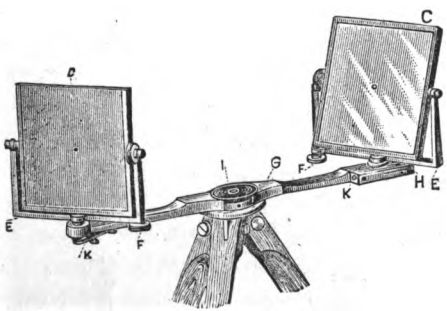
M. Shutter.

N. Key for shutter.

22. The sun mirror has an unsilvered spot at its center, the station mirror a paper disk. In other respects they are similar. The tangent-screw attachment to the frame affords the means



(Latest style shutter has six leaves)



of revolving the mirror about a horizontal axis.

The support to the frame has a conical projection accurately turned to fit the socket of the mirror bar and grooved to receive the clamp spring.

The shutter has leaves, operated by means of a key.

The base of the frame carries a female screw for attachment to the tripod.

23. The sighting rod is fitted to the socket of the mirror bar, and is clamped in the same manner as the mirrors. It carries at one end a movable disk, which when turned down reveals the front sight. A piece of white paper should be slipped into the disk to receive the "shadow spot," and a slight puncture made therein, coincident with the point of the front sight, as guide in adjustment. Vertical adjustment of the disk is made possible by loosening the milled slide.

24. The mirror bar is provided with a clamp threaded to fit the screw of the tripod. The release of the clamp permits movement of the bar independent of the screw. At one end is at-

tached the tangent screw for revolving mirror about a vertical axis, and it should be remembered that *under all circumstances the sun mirror is to be clamped to this end,* while the socket at the other extremity is designed to receive the station mirror or the sighting rod. A movable spring is placed under each end of the bar for clamping mirrors and sighting rod.

25. The tripods are similar, the screw of either serving equally well for the attachment of mirror bar or shutter.

Both are provided with a hook for the suspension of a weight, to give great stability when required.

SETTING UP AND ADJUSTING

26. The position of the sun is the guide for determining whether one or two mirrors should be used. When the sun is in front of the operator—that is, in front of a plane through his position, at right angles to the line of vision—the sun mirror only is required. With the sun in rear of this plane both mirrors should be used, although a single mirror may often be worked to advantage with the sun well back of

the operator. In the former case the rays of the sun are reflected from the sun mirror direct to the distant station. In the latter they are reflected from the sun mirror to the station mirror, thence to the distant station.

27. *With one mirror:* Set the tripod firmly on the ground, attach the bar to the tripod, insert and clamp in their appropriate sockets the sun mirror and the sighting rod, the latter with its disk turned down. Sight through the center of the mirror and turn the bar and raise or lower the sighting rod until the center of the mirror, point of sighting rod, and distant station are accurately in line; then clamp the bar firmly to the tripod, being careful not to disarrange the alignment.

Turn up the disk of the sighting rod. Move the mirror by means of the slow-motion screws until the "shadow spot" falls upon the disk of the sighting rod. The flash will then be visible to the distant observer.

The shadow spot must be kept in the center of the disk while signaling, and should be kept there by constant adjustment of the mirror. At-

tach the shutter to the tripod, and place it close to and in front of the sighting disk so as to intercept the flash.

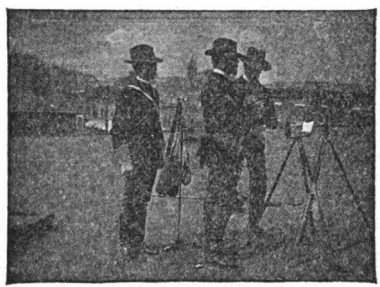
28. *With two mirrors:* Set the tripod firmly on the ground, clamp the bar diagonally across the line of vision to the distant station, clamp the sun mirror facing the sun to the end of the bar with tangent-screw attachment, and the station mirror facing the distant station to the other socket.

Stooping down, the head in rear of and near the station mirror, turn the sun mirror by means of its slow-motion screws until the whole of the station mirror is seen reflected in the sun mirror, and the unsilvered spot and reflection of the paper disk accurately cover each other. Still looking into the sun mirror, turn the station mirror until the reflection of the distant station is brought accurately into line with, or is covered by, the unsilvered spot and the reflection of the paper disk. After this the station mirror must not be touched.

Now, stepping behind the sun mirror, throw upon the station mirror a full flash from the

sun mirror, so that the shadow spot falls upon the center of the paper disk. The flash will then be visible at the distant station.

The shadow spot must be kept in the center of the disk while signaling, and should be kept there by constant adjustment of the mirror. At-



Heliograph station, roof of warehouse.

tach the shutter to its tripod and place it so as to intercept the flash from the station mirror.

29. Signaling is effected by depressing the shutter key for periods of time required to display flashes.

A dot is represented by a momentary exposition of the flash.

A dash by a long steady flash.

It is of the utmost importance that uniformity in mechanical movement of the shutter be cultivated, as lack of rhythm in the signals of the sender entails unnecessary and vexatious concentration of attention upon the receiver.

The flashes should be sharp and clear cut.

REMARKS

30. In setting up the instrument, spread the tripod legs sufficiently to give a good base, and on yielding soil press firmly into the ground, the head approximately level. In a high wind, ballast by hanging a substantial weight to the hook.

If the legs become loose at the head joints, apply the screw-driver to the assembling screws.

31. See that the shutter completely obscures (cuts off) the flash, also that the flash passes entire when the key is depressed.

The spring should return the shutter sharply to its normal position when the key is released. If it fails to respond promptly, strengthen or replace.

32. *Extra care bestowed on preliminary adjustment is repaid by increased brilliancy of flash.* With alignment absolutely assured, and the shadow spot at the center of the disk, the axis of the cone of reflected rays is coincident with the line of sight, and the distant station receives the greatest possible intensity of light.

The distant operator is necessarily the best judge as to the flash received; if, therefore, adjustment is called when the shadow spot is at the center of the disk, *alignment is at fault.*

Accuracy of alignment may be tested by looking into the sun mirror, bringing the eye into line with the unsilvered spot, the reflection of the disk, and reflection of the distant station. If it is found that a line through the center of the unsilvered spot and reflection of the disk strikes a little to one side of the reflection of the distant station, grasp the mirror bar firmly, without loosening the clamp, and slightly turn it, so that the reflection of the distant station will be brought accurately into line. If the reflection of the distant station appears slightly above or below a line through the center of the

unsilvered spot and reflection of the disk, bring it into line by pressing the front or rear tripod legs farther to the ground, as the case may require.

33. The tendency of the shadow spot to move off the disk, due to the apparent motion of the sun, is compensated for, without interrupting signals, by means of the tangent screws of the sun mirror. The movement imparted to the mirror by these screws does not disturb alignment, as its center (the unsilvered spot) is at the intersection of the axes of revolution.

34. The manipulation of the instrument involves but slight manual labor; the strain on the eyes, however, from the flash of the mirror in receiving, is often considerable, but may be modified by the use of stained glasses.

Ability to read signals from the heliograph may be readily acquired, but may also be as readily lost if practice be discontinued before proficiency is attained. It should therefore be the endeavor to acquire such facility, not only in sending but in receiving, that habit will come

to the aid even after the lapse of considerable time.

35. Minor parts of the instrument should be dismounted only to effect repair. All steel should be preserved from rust, and tangent screws and bearings from dust and grit. The mirrors should invariably be wiped clean before using.

In case of accident to the sun mirror the station mirror may be made available as such by removing the paper disk.

36. The projection of the rays of the sun upon a screen, by reflection from plane mirrors, demonstrates that for short distances (varying with the size of the mirrors employed) the figures of illumination are similar to those of the mirrors used. Removing the mirrors to a greater distance from the screen, it is found that the shapes of the mirrors are no longer reflected, but that all images are circular and of the same diameter.

Removing the mirrors to a still greater distance, it is found that the various images are circular as before and of the same diameter, but that this latter diameter is greater than the one

previously obtained. Repeating the experiment at increased distances, these results are confirmed, with the following conclusions:

a. That up to a certain distance the form of the mirror is reflected upon the screen.

b. That this distance once exceeded, the reflected images obtained from mirrors of various shapes and sizes are all circular and of equal diameters at equal distances.

c. That the greater the distance from the mirror to the screen, the greater the diameter of the reflected image.

d. That the images vary in brightness, the larger mirrors producing the brighter images.

It is therefore evident that the advantage derived from the use of a large mirror consists, not in any increase in the size of the flash, but in an increase of brightness—that is, capability of overcoming such obstructions as fog, smoke, haze, and consequently distance.

37. The light from the sun is projected upon the surface of the mirror in a cone of rays, and is reflected in a cone of the same dimensions. The angle within which the reflection is visible

is that subtended by the diameter of the sun. The limit of the lateral extension of the flash at any given distance may therefore be definitely determined.

It is found that the circle of illumination has a diameter which increases sixteen and one-third yards for every mile of distance from the mirror.

As the diameter of the flash increases directly with the distance between stations, adjustment of the instrument is quite as simple and certain for great as for short distances. Although the margin of flash is ample, so that signals may be directed upon a station, however distant, with certainty, yet it is so slight relative to the distance between communicating points that signals are invisible to one far out of the direct line, and are therefore not liable to be read by those for whom not intended.

38. The range over which signaling may be effected under favorable atmospheric conditions is limited only by the convexity of the earth. The square mirror is adopted in preference to the round, as containing about one-fourth more

reflecting surface for practically the same packing space.

Signaling at night, in the squad room, may be effected by the employment of artificial light.

39. *Powers and limitations of the heliograph.* —Portability, great range, comparative rapidity of operation, and the invisibility of the signals, except to observers located approximately on a right line joining the stations between which communication is had, are some of the advantages derived from using the heliograph in visual signaling.

The principal disadvantages result from the entire dependence of the instrument upon the presence of sunlight and that when within range it is an attractive target. The normal working range of the heliograph is about 30 miles, under favorable circumstances though, instances of its having attained ranges many times greater than this are of record. The heliograph can be depended upon to transmit from 5 to 12 words per minute.

FIELD STATIONS

40. Each station should have its own signal or call letter. A terminal station should be manned by a non-commissioned officer and three men, and an intermediate station by an officer and six men. A central station requires three men to each station with which it is in communication.

Continuous work requires a sufficient number of men to form three reliefs. Each relief should consist of the number of men stated above. The tour for each relief should be four hours.

41. When signaling with the flag, one man calls off the letters, another sends, while the third watches the distant station.

In receiving, one of the men reads, one records, and the other is stationed at the sending point, with flag at "front," to break if necessary.

When signaling with a heliograph, one man calls off, one sends, and the third keeps adjust-

ment. The man sending keeps watch of the distant station. In receiving, one man reads, another records, and the third keeps adjustment. The man who reads stands at shutter to break if necessary.

If the recorder sees that a word is not intelligible, or if the readers are in doubt about a letter, the sender immediately breaks the sending station and signals "Interrogatory A," followed by the last word correctly received.

42. The officer or non-commissioned officer in charge of the station is responsible for everything in connection with it. He gives his entire attention to the working of the station, and *will compel each member of the party to attend strictly to his own business.* He continually notes the correctness of the adjustment of the heliograph, and tests its alignment from time to time. He has charge of the apparatus and equipments, and sees that all messages are correctly copied and transmitted, either to the communicating station or to the person for whom they are intended.

The person in charge of a station may never

take it upon himself to make any alterations in a message. He must bear in mind the confidential nature of the work, and will see that unauthorized persons do not loiter about the station, and that no one interferes with the work of the party. No talking can be allowed while actual work is going on, beyond the necessary calling off, and giving of orders.

An exact copy of every message sent and received must always be kept, with date and hour of receipt and transmission.

Communications transmitted by signals are always confidential, and will only be revealed to those officially entitled to receive them.

43. A strict watch upon all other stations, and upon points from which calls are likely to come, must be kept at all times.

Failure promptly to recognize and reply to calls, or correctly to receive and transmit messages, is punishable, in case of either officers or enlisted men, as neglect of duty.

In case the sending station cannot get an answering signal, but has reason to believe that its

own signals are visible, it should send the message repeatedly.

It must be remembered that it is the duty of the signal corps to transmit messages, and any excuse for a failure to do so may well be received with ill grace. Faithful, persistent, and, it may be, desperate efforts, must be made to fulfill requirements, though in the face of unlooked-for and adverse circumstances.

44. It should be remembered that accuracy is of paramount importance, and rapidity in signaling must always be subordinated to it. If any doubt as to a character exists, the sender will be required to repeat it.

45. In field work it is imperative that the greatest care be taken in selecting the station.

Stations ought not, when it can be avoided, to be located exactly on an east and west line, or in the line of the apparent course of the sun. It is impossible to signal in the line of the rising or setting sun, not only on account of the blinding light, but because of the haze in which the landscape in the direction of the sun is very liable to seem to be enveloped.

A station should not, if avoidable, be located in a camp, or where the white canvas of tents is liable to form the background. The maneuvering of troops in an encampment, the passage of individuals, the smoke from the kitchens, and the curiosity of persons not attached to the station, make a camp the most unsuitable locality for a signal station.

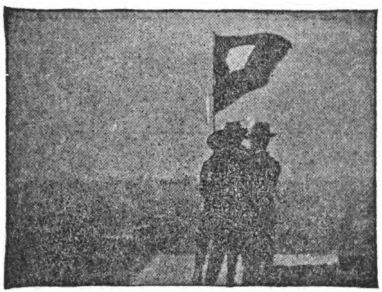
The point chosen should be near the headquarters of the commanding officer, but outside of the camp and on one side of it. If no natural height presents, a platform may be built in the top of a tree, or a scaffold erected from the ground.

46. Stations should invariably be on the most elevated ground accessible, and should never, if avoidable, be placed on low land. The undulation of the atmosphere noticeable on a hot summer day is always less at a distance from the earth's surface, while in the cool night air the smoke and dust of the day and the heavy moving mists lie close to the ground, obscuring the lowlands.

Stations on the tops of city buildings should,

when possible, be so located as not to be visible from the street.

47. Signal officers should always be supplied



Flag station, parapet of high building.

with the best obtainable maps of the district in which they may be working.

The maps should have altitudes indicated in figures. In selecting stations from a map and calculating the height of intervening elevations, due allowance should be made for the curvature of the earth.

48. The following table shows the extent of horizon for different heights above the sea

level; that is, it shows how far an object at the sea level can be seen.

Height of the eye above sea level (in feet)	Distance (in statute miles)	Height of the eye above sea level (in feet)	Distance (in statute miles)
10	4	115	14
15	5	130	15
20	6	150	16
30	7	200	18
40	8	230	20
50	9	300	23
60	10	350	25
70	11	500	30
85	12	700	35
100	13	900	40

Hence, an observer whose eye is 30 feet above the sea can distinguish an object 7 miles distant, providing it is at the sea level; but if the object is itself 15 feet above the sea he can make it out $7 + 5 = 12$ miles off.

Officers should enter in the field books, provided for the purpose, sketches and minute descriptions of the location of stations upon which they have worked, showing upon the sketch,

lines leading to other stations with which communication may be held, with magnetic courses to the same, and any notes or information which might aid in quickly locating the station at some future time.

49. In signaling with the flag, *the background is of vital importance.*

It should be of one color, and the flagman should be so placed that all the motions will be outlined against it when viewed from the communicating station. Dark colored backgrounds, such as green fields or woods, are the most satisfactory. Sky backgrounds are excellent, but are difficult to obtain.

The background may be a long distance, sometimes many miles, behind the station. To determine what the background will be, move along the line of vision in front of your station, the head accurately in line with the distant station, and observe your background from that position.

The flag used must be of the color which contrasts most greatly with the color of the background. In the case of landscape backgrounds

the white flag should be used. With sky backgrounds use black flags. With mixed backgrounds, red flags. In nine cases out of ten the white flag will be found best.

50. It is important that every motion and position of the flag be visible at the receiving station. It is possible that trees or bushes may hide the flag in one of its motions, although they be a long way off.

To determine that the flagman is so placed that nothing obstructs a view of the flag in any of its motions, when viewed from the receiving station, go to the points to the right, left, and front of the flagman, and, stooping down, with the face at about the height of the flag at its lowest point, see if the farther station be visible from there. If so, then rise, and see if the farther station is visible as you rise.

The above precaution should always be taken.

51. When signaling with the heliograph, it will often be necessary, in opening communication, to find the direction by compass. After the course has been found the instrument should be sighted as nearly as possible on the point

where the distant station is supposed to be, and the flash swept by the slow motion screws slowly back and forth in a small arc, occasionally changing it to a little higher or lower plane.

Attention may often be attracted by taking a spare mirror and flashing it toward the distant station. The flash may be directed by selecting some near object nearly in line with the distant station, as a reference point.

THE ARDOIS SYSTEM

GENERAL SERVICE CODE

52. The Ardois system, used in the United States Army and Navy, is a display of four lights, each of which may be made either red or white. These lights are incandescent lamps, operated by a keyboard conveniently placed at the station. The red light indicates a dot and the white light a dash, so that the characters of the General Service Code are made by combinations of red and white lights.

If the lights are arranged vertically, as when swung from a staff or spar, they are read from the top downward. If the lights are placed horizontally, they are read from the sender's right to his left.

Example: Red-white, or dot-dash, represents the letter A; and white-red-red-red, or dash-dot-dot-dot, represents the letter B.

For numerals in the Ardois system, second-

ary meanings (as numerals) have been assigned to the last 10 letters, Q being 1, R being 2, and so on, Z being 0. These secondary meanings are not used in communicating with the Navy; when communicating with the Navy the numerals of the International Morse Code must be spelled out in full.

RULES FOR USING THE ARDOIS SYSTEM OF SIGNALING

53. In signaling by the Ardois system the Cornet, WWWW, is a general call to attention. A station desiring to exchange signals will display the call letters of the station wanted, which will be answered by a similar display from the station called, or from each station successively called.

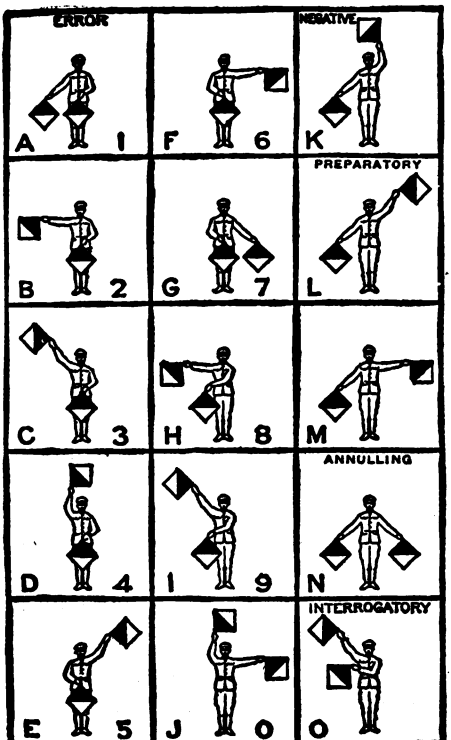
If the call letters of a station be unknown, display the Cornet.

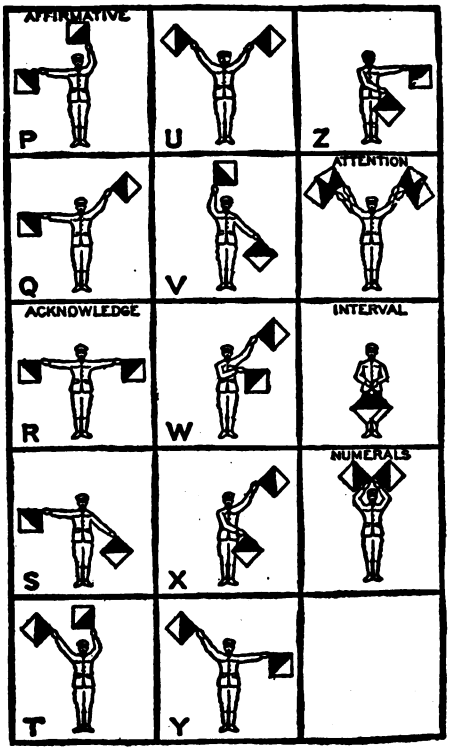
The calls having been answered, proceed with the message, or if a special or preconcerted code is to be used, so indicate, and when answered proceed with the message.

If it becomes necessary to put a signal message into cipher, the marking of the Ardois keyboard is on no account to be changed to accomplish this object.

HAND FLAGS

54. Hand flags are authorized for general use by the Army, though on account of their small range they are of limited application, and are chiefly serviceable for use within organizations, within fixed positions, or for incidental signaling. The range with flags of the usual size is of course dependent upon light and background, but is seldom more than one mile with the naked eye. This system of signaling has been highly developed in the Navy, and on account of its rapidity and simplicity is of use to the Army and should be familiar to all soldiers. It is limited to visual signaling work and not adapted to general signaling, as is the General Service Code. It will be found useful under many circumstances and is adapted to special work when rapid communication for short distances is needed. This method is also used to advantage for interior signaling within batteries of the field





artillery and regiments of infantry, and will, at times, be convenient for the cavalry.

55. The semaphore hand flags for service use are 18 inches square, divided diagonally into two parts, one of red and the other of white; the staffs are 24 inches long.

For the field and the coast artillery there is now issued a semaphore hand flag of orange with a scarlet center and scarlet with an orange center, one of each constituting a kit. The flags are 18 inches square, the centers 9 inches square, and the staffs 24 inches long.

56. The hand flags of the Navy are from 12 to 15 inches square, of blue with a white square, or red and yellow diagonally, the colors to be used depending upon the background. The flags are usually attached to a light wooden staff about 2 feet in length.

57. In making the intervals the flags are crossed downward in front of the body (just above the knees); the double interval is the "chop-chop" signal made twice. The triple interval is "chop-chop" signal made three times. In calling a station face it squarely and make

its call. If there is no immediate reply wave the flags over the head to attract attention, making the call at frequent intervals. When the sender makes "end of message" the receiver, if message is understood, extends the flags horizontally and waves them until the sender does the same, when both leave their stations. Care must be taken with hand flags to hold the staffs so as to form a prolongation of the arms.

LETTER CODES

INFANTRY

58. For use with General Service Code or semaphore hand flags.

Letter of alphabet.	If signaled from the rear to the firing line.	If signaled from the firing line to the rear.
AM	Ammunition going forward.	Ammunition required.
CCC	Charge (mandatory at all times).	Am about to charge if no instructions to the contrary.
CF	Cease firing.	Cease firing.
DT	Double time or "rush."	Double time or "rush."
F	Commence firing.	
FB	Fix bayonets.	
FL	Artillery fire is causing us losses.	
G	Move forward.	Preparing to move forward.
HHH	Halt.	
K	Negative.	Negative.
LT	Left.	Left.

Letter of alphabet.	If signaled from the rear to the firing line.	If signaled from the firing line to the rear.
O ..... (Ardois and semaphore only.)	What is the (R. N., etc.)? Interrogatory.	What is the (R. N., etc.)? Interrogatory.
. . — — . . (All methods but ardois and semaphore.)	What is the (R. N., etc.)? Interrogatory.	What is the (R. N., etc.)? Interrogatory.
P	Affirmative.	Affirmative.
RN	Range.	Range.
RT	Right.	Right.
SSS	Support going forward.	Support needed.
SUF	Suspend firing.	Suspend firing.
T	Target.	Target.

CAVALRY

59. For use with General Service Code or semaphore hand flags.

AM—Ammunition going forward (if signaled from the rear to the front).

Ammunition required (if signaled from the front).

CCC—Charge (if signaled from the rear to the front).

CCC—About to charge if no instructions to the contrary (if signaled from the front).

CF—Cease firing.

DT—Double time, rush, or hurry.

F—Commence firing.

FL—Artillery fire is causing us losses.

G—Move forward (if signaled from the rear to the front).

Preparing to move forward (if signaled from the front).

HHH—Halt.

K—Negative.

LT—Left.

M—Bring up the horses (if signaled from front to rear).

Horses going forward (if signaled from rear to front).

O—What is the (R. N., etc.)? Interrogatory. (Ardois and semaphore only.)

..——..—What is the (R. N., etc.)? Interrogatory. (All methods but ardois and semaphore.)

P—Affirmative.

R—Acknowledgment.

RN—Range.

RT—Right.

SSS—Support going forward (if signaled from the rear to the front).

Support needed (if signaled from the front).

SUF—Suspend firing.

T—Target.

FIELD ARTILLERY

60. For use with General Service Code or semaphore hand flags.

.....—Error. (All methods but ardois and semaphore.)

A—Error. (Ardois and semaphore only.)

AD—Additional.

AKT—Draw ammunition from combat train.

AL—Draw ammunition from limbers.

AM—Ammunition going forward.

AMC—At my command.

AP—Aiming point.

B (numerals)—Battery (so many) rounds.

BS (numerals)—(Such.) Battalion station.

BL—Battery from the left.

BR—Battery from the right.

CCC—Charge (mandatory at all times). Am about to charge if not instructed to contrary.

CF—Cease firing.

CS—Close station.

CT—Change target.

D—Down.

DF—Deflection.

DT—Double time. Rush. Hurry.

F—Commence firing.

FCL (numerals)—On 1st piece close by (so much).

FL—Artillery fire is causing us losses.

FOP (numerals)—On 1st piece open by (so much).

G—Move forward. Preparing to move forward.

HHH—Halt. Action suspended.

IX—Execute. Go ahead. Transmit.

JI—Report firing data.

K—Negative. No.

KR—Corrector.

L—Preparatory. Attention.

LCL (numerals)—On 4th piece close by (so much).

LOP (numerals)—On 4th piece open by (so much).

LT—Left.

LL—Left from the left.

LR—Left from the right.

LE (numerals)—Less (so much).

MD—Move down.

ML—Move ° to your left.

MR—Move to your right.

MU—Move up.

MO (numerals)—Move (so much).

N—Annul, cancel.

O—What is the (R. N., etc.)? Interrogatory. (Ardois and semaphore only.)

. . — — . .—What is the (R. N., etc.)? Interrogatory. (All methods but ardois and semaphore.)

P—Affirmative. Yes.

PS—Percussion. Shrapnel.

QRQ—Send faster.

QRS—Send slower.

QRT—Cease sending.

R—Acknowledgment. Received.

RS—Regimental station.

RL—Right from the left.

RR—Right from the right.

RN—Range.

RT—Right.

S—Subtract.

SCL (numerals)—On 2nd piece close by (so much).

SOP (numerals)—On 2d piece open by (so much).

SH—Shell.

SI—Site.

SSS—Support needed.

T—Target.

TCL (numerals)—On 3d piece close by (so much).

TOP (numerals)—On 3d piece open by (so much).

U—Up.

Y (letter)—Such battery station.

EMERGENCY SIGNALS

61. The following emergency signals may be employed by the Army when circumstances permit and conditions justify and when authorized by officers in immediate command of station or troops using them.

These signals are designed to call attention of persons within their radius, and all such persons should pay instant heed to them. They may indicate distress; ask assistance; give a general alarm in case of riot, attack, flood, or conflagration, or may be used for other urgent reasons.

Their purpose and meaning should be designated beforehand. When authorized, information regarding their meaning and use must be given to troops and other persons entitled to receive or send these signals and to all those who should be familiar with their meaning.

These signals will never be used without good cause.

EMERGENCY SIGNALS FOR USE ON CABLE AND TELEGRAPH LINES

62. The general attention or emergency call for use on cable or land telegraph lines is the numeral "9." It will be sent out only by the proper authority and will have its meaning clearly understood. Upon hearing the call, all operators will give way, but they will remain at their instruments until relieved. They will not cut in unless called. The numeral "9" as an emergency call may be used in anticipation of attack or riot; it may be used to indicate a conflagration or other danger and should be used only in case of need. This signal is of great importance and should be thoroughly understood by all cable and telegraph operators. It should be conspicuously posted with appropriate instructions as to its meaning and use in all cable and telegraph stations.

EMERGENCY SIGNALS FOR USE IN RADIOTELEGRAPHY

63. The radio distress signal for use at sea is the international signal SOS. It is a universal signal and is of paramount importance. Its

meaning should be thoroughly understood by all radio operators, and should be conspicuously posted with appropriate instructions in all radio stations of the Army whether on ship or ashore.

The operator of any Army radio station aboard ship, upon receiving an SOS signal, will immediately ascertain the exact position, in latitude and longitude, of the vessel sending the signal. When this information has been received, the operator will immediately have the same delivered to the officer in charge of the ship, who will take the necessary action.

NOTICE TO BE POSTED IN ALL RADIO STATIONS

64. The following is from the report of the International Radiotelegraphic Conference, London, 1912:

Ships in distress shall make use of the following signal:

... — — — ...

repeated at short intervals, followed by the necessary particulars.

As soon as a station hears the signal of distress, it must suspend all correspondence and

must not resume the same until after it has made sure that the communication consequent upon the call for help is finished.

The stations which hear a call of distress must act according to the indications given by the ship which makes the call, with regard to the order of messages or their cessation.

When, at the end of a series of distress calls, there is added the call-signal of a particular station, the reply to the call is proper to that station only, unless that station does not reply. Failing the indication of a particular station in the call for help, every station that hears the call shall be bound to reply thereto.

SIGNALS OF DISTRESS ON ARMY TRANSPORTS, AND VESSELS UNDER CONTROL OF THE ARMY

65. The signal of distress on Army transports shall be, either together or separately, as follows:

In the daytime—

First. A gun or other explosive signal fired at intervals of about one minute.

Second. The International Code signal of distress indicated by NC.

Third. The distance signal, consisting of a square flag having either above or below it a ball or anything resembling a ball.

Fourth. A continuous sounding with any fog-signal apparatus.

At night—

First. A gun or other explosive signal fired at intervals of about one minute.

Second. Flames on the vessel (as from a burning tar-barrel, oil barrel, etc.).

Third. Rockets or shells throwing standard Army transport night signals, fired one at a time, at short intervals.

Fourth. A continuous sounding with any fog-signal apparatus.

These signals require no answer, but any station hearing or seeing them should make every effort to assist the ship in distress.

On Army transports the fire signal is the continuous and rapid ringing of the ship's bell for a period of not less than 20 seconds, and this signal shall not be used for any other purpose

whatsoever. An emergency or alarm signal, indicating the approach of danger from rocks, shoal water, collision, etc., is made by the rapid and continuous short blasts of the whistle.

These signals will apply, so far as practicable, to all vessels under the control of the War Department, both in peace and war.

EMERGENCY SIGNALS WITH BOMBS (OR OTHER EXPLOSIVE), SMALL ARMS, OR THE NATIONAL ENSIGN

66. A general attention or alarm signal, indicating attack, riot, conflagration, or other emergency, will be made by sound signals, when authorized as previously indicated, by one discharge of a cannon, rifle, pistol, or *smoke* bomb by day, followed by a smoke rocket at half-minute intervals. At night, by one discharge of cannon, small arm, or *light* bomb, followed by a red rocket at half-minute intervals. This signal requires no answer.

Used as an emergency signal it will serve to call all troops to attention, and should be followed by a preconcerted signal to indicate the

character of the alarm given or to communicate instructions. As an instance, a smoke bomb followed by a rocket is a call to attention and will indicate riot or attack, upon receiving which all troops will fall into ranks under arms. Should the first rocket be followed by a second, the signal will indicate a conflagration or other danger, and all troops noting it will fall into ranks prepared to fight fire or to meet other danger (such as flood).

If no bombs or rockets are at hand at the camp or station for use with sound signals of this character, a general-alarm signal will be made by a rapid discharge of shots. None of these signals requires an answer.

With the national flag the distress signal, universally understood is made by flying the ensign union down.

EMERGENCY SIGNALS BY SOUND WITH BELL, WHISTLE, FOGHORN, BUGLE, TRUMPET, OR DRUM

67. General attention, distress, or alarm signals may be made by rapidly repeated strokes of the bell, blasts of foghorn or whistle, call of bu-

gle or trumpet, or tap of drum. These signals, explained beforehand and thoroughly understood, require no acknowledgment, but should be acted upon immediately.

In addition to the dot and dash signals, the bugle, the trumpet, and the whistle may be used for signaling as in the Drill and Field Service Regulations of the Army.

The long roll of the drum will be recognized as an emergency signal. When used in the Army it is a general-alarm signal and requires all troops to fall into ranks.

68. *It is recommended that the instructions regarding emergency signals, their use and meaning, be posted in all radio and signal stations of the Army, at headquarters in garrison or in the field, at the guardhouse of military posts, at the guard tents of troops in the field, and that they be communicated as part of the instructions to officers and to soldiers on guard duty.*

MESSAGES IN CIPHER

69. In active service all messages should be transmitted in cipher. The United States Army cipher disk consists of two disks fastened concentrically together in such a way that they may be revolved one upon the other.

Around the edge of the larger disk the alphabet is written from left to right; on the smaller one, from right to left.

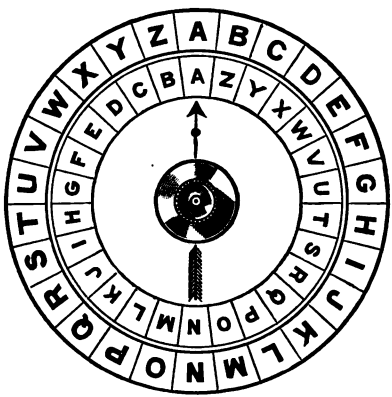
If there be no previous agreement, "A" on the inner circle will be set opposite "A" of the outer circle.

The letters of the message, which is written in plain English, are found on the one circle, and the letters opposite them on the other circle signaled.

The operator at the receiving station writes the message down as it is sent, and afterward translates it by using his own disk, which should be adjusted the same as that of the sender.

70. It is usual to agree on a cipher word in

advance. The message is divided into groups of five letters each. The first *group* is enciphered by setting the arrow on the inner disk at the first letter of the cipher word on the outer circle. The second group is enciphered by setting the arrow at the second letter of the cipher



word, and so on. When all the letters of the cipher word have been used in turn, commence at the first letter again.

In signaling, a front or space signal is made after each group.

In enciphering or deciphering a message, it makes no difference which disk the letters are found on. The result is the same whether one finds a letter on the outer circle and records the letter opposite it on the inner circle, or finds the letter on the inner circle and records the letter opposite it on the outer circle. The circles may be used indifferently.

71. Messages sent in cipher should, to prevent errors, be repeated back by the receiving station. This should be done group by group—i. e., as soon as a group of four letters is received, it should be repeated back before the next group is sent.

Cipher dispatches to which the key is unknown may often be deciphered by the rule of frequency of occurrence of letters.

The order of precedence among the letters, according to the frequency of their occurrence, is as follows: e, a, o, i, t, d, h, n, r, s, u, y, c, f, g, l, m, w, b, k, p, j, q, x, z.

The most frequent compounds are: th, ng, ee, ll, mm, tt, dd, and nn.

72. Important dispatches by courier should

not only be written in cipher, but may be written in invisible ink made as follows:

Chloride of cobalt..... 50 grains;
Distilled water ..... 1 fluid ounce;
Glycerin ..... 10 minims.

Dissolve the chloride of cobalt in the distilled water and add the glycerin.

Writing executed with this ink is invisible on paper, but, on warming, the writing turns blue. On exposure to damp air it becomes invisible again.

73. In long range signaling with a heliograph and in much other signal work it will often be necessary to use the compass, especially when the line and stations are selected by the map. In finding the course from one station to another by the map it must be remembered that the meridian lines run toward the true north while the compass needle points to the magnetic north. A compass is of no assistance unless its use is thoroughly understood. It is not as simple to use as a watch and in itself does not point a course as a weather vane points into the wind.

74. The best compass for military work is that called the "Box Compass" mounted in a square wooden box about three inches on a side. It is graduated to degrees and reads from zero around to 360 degrees, zero being the north point. The north and south line is at right angles to the side to which the cover is hinged, and the cover has a sighting line cut in its underside,

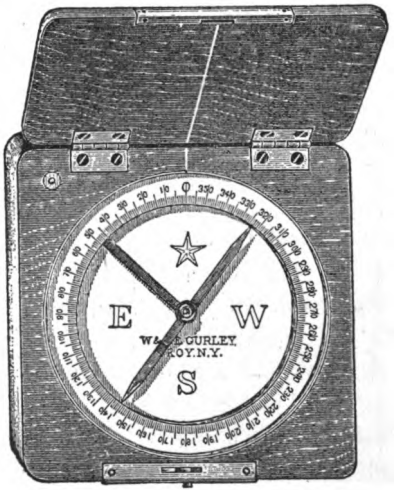
so that when open the line is in prolongation of the north and south line of the dial.

In this compass the west is on the right-hand side of north, and east on the left hand, so that when the needle points to the given bearing the sight line will point in the desired direction. This saves calculation and confusion; but when *taking* a bearing with the compass it must be borne in mind that the east and west are reversed.

75. In using a compass it should be borne in mind that the needle always points in a known direction, but that direction is not north, at least the needle points to true north only in a few places. The needle points to the magnetic north pole, which is nowhere near the geographical pole. The difference in direction between the magnetic north and true north is called the "declination" or "variation" of the compass and is measured by degrees. The variation for the locality in question must be known or you will go far astray. For example, the declination in East New Brunswick is 25 degrees west, in Central Michigan 0, and in Vancouver Island

25 degrees east (see table of magnetic declination in the United States).

76. To illustrate the declination of the com-



pass, take the map of the United States, draw a line from Mackinac Island, in Lake Michigan, to Savannah, Georgia. At all points on this line, roughly speaking, the compass needle points

to true north. At all points east of this line, which is called the Agonic line or Zero Curve, the north end of the needle points to the west of true north and at all points west of the line to the east of true north. The farther you are away from the Agonic line the greater the declination of the needle. The declination increases east or west from the line at about the rate of one minute per mile—one degree in sixty miles.

77. In finding the magnetic course on a map with a protractor, allowance must be made for the variation of the needle. If the protractor reading between two points be on that side of north to which the needle varies, the amount of the variation must be *subtracted* from the protractor reading to get the magnetic course. If the protractor reading between the points be on the opposite of north from that to which the needle varies, then the variation must be *added* to the reading to get the magnetic course.

78. In using a map spread it out flat and lay the compass on it with the N-S line parallel to the N-S line of the map. Revolve the map until the needle points to the proper amount of dec-

lination and all lines on the map *will be parallel with the lines they represent* on the ground.

79. Look out for local attraction; a rifle or other iron or steel may deflect the needle. Rubbing of the exposed glass of the compass may magnetize it and attract the needle. This attraction may be dissipated by touching it with a wet finger.

80. The amount of declination at a given point is constantly changing as the Agonic line is moving west quite rapidly. All west declinations are increasing and all east declinations decreasing. A chart showing the Agonic line and lines of equal magnetic declination may be obtained from the U. S. Coast and Geodetic Survey, but it is unnecessarily complicated for ordinary use. None of the lines are straight. They are irregular and in places tortuous, resembling topographic contour lines. For ordinary use the table of magnetic declinations is sufficiently accurate.

Military compasses are of many patterns and some of them very complicated. They are extremely accurate in expert hands, but are for

the use of trained officers, topographers and engineers rather than for soldiers.

Radiumized prismatic night marching and field sketching compass.

TABLE OF APPROXIMATE MAGNETIC DECLINATION AT VARIOUS POINTS IN THE UNITED STATES—1917

Locality	*Declination*
Alabama	
Eastern part	3° E
Western part	4° E
Arkansas	
Eastern part	6° E
Western part	7° E
Arizona	
Southeastern part	13° E
Central part	14° E
Northwestern part	15° E
California	
Los Angeles	15° E
Tulare Lake	16° E
San Jose	17° E
Sacramento	18° E
Northwestern part	19° E

Locality	*Declination*
Colorado	
Southeastern part	13° E
Central part	14° E
Northwestern part	15° E
Connecticut	
New London	12° W
Stamford	10° W
Delaware	6° W
District of Columbia	5° W
Florida	
Eastern coast	1° E
Western coast	2° E
Pensacola	4° E
Georgia	
Eastern part	1° E
Central and western parts	2° E
Idaho	
Southeastern part	18° E
Central part	20° E
Extreme northwest	22° E
Illinois	
Eastern part	3° E

Locality	*Declination*
Central part	5° E
Western part	6° E
Indiana	
Eastern part	1° E
Central part	2° E
Western part	3° E
Iowa	
Eastern part	6° E
Des Moines	8° E
Western part	10° E
Kansas	
Eastern part	9° E
Wichita	10° E
Western part	12° E
Kentucky	
Eastern extremity	No variation
Central part	2° E
Western part	4° E
Louisiana	
Eastern part	6° E
Western part	7° E
Maine	
Portland	15° W

Locality	*Declination*
Bangor	17° W
Northern part	20° W
Maryland	
Baltimore	6° W
Cumberland	4° W
Massachusetts	
Boston	13° W
Worcester	12° W
Pittsfield	11° W
Michigan	
Detroit	2° W
Central part	No variation
Western part	1° E
Minnesota	
Eastern part	7° E
Western part	10° E
Mississippi	
Eastern part	5° E
Western part	6° E
Missouri	
St. Louis	6° E
Central part	7° E
Western part	8° E

Locality	*Declination*
Montana	
Southeastern part	17° E
Yellowstone County	19° E
Helena	20° E
Missoula	21° E
Nebraska	
Lincoln	10° E
Grand Island	12° E
Sidney	14° E
Nevada	
Southern part	16° E
Central part	17° E
Northern part	18° E
New Hampshire	
Manchester	13° W
Lake Winnepesaukee	14° W
White Mountains	15° W
Northern part	16° W
New Jersey	
Southern part	7° W
Central part	8° W
Northern part	9° W

Locality	*Declination*
New Mexico	
Southeastern part	11° E
Central part	13° E
Northwestern part	14° E
New York	
Buffalo	6° W
Rochester	7° W
Syracuse	9° W
New York City	10° W
Albany	11° W
Adirondacks	12° W
Plattsburg	14° W
North Carolina	
Cape Hatteras	4° W
New Berne	3° W
Raleigh	2° W
Great Pedee River	1° W
Asheville	No variation
North Dakota	
Eastern part	12° E
Central part	15° E
Western part	17° E

Locality	*Declination*
Ohio	
Eastern part	3° W
Central part	1° E
Western part	No variation
Oklahoma	
Eastern part	8° E
Western part	10° E
Oregon	
Southern part	20° E
Central part	21° E
Northern part	22° E
Pennsylvania	
Philadelphia	8° W
Williamsport	7° W
Altoona	5° W
Pittsburgh	3° W
Rhode Island	12° W
South Carolina	
Eastern part	1° W
Central part	No variation
South Dakota	
Eastern part	10° E

Locality	*Declination*
Central part	13° E
Western part	15° E
Tennessee	
Eastern extremity	No variation
Central part	4° E
Western part	5° E
Texas	
Eastern part	8° E
Dallas	9° E
Milene	10° E
Western part	11° E
Utah	
Southern part	15° E
Central part	16° E
Salt Lake	17° E
Vermont	
Southern part	13° W
Central part	14° W
Northern part	15° W
Virginia	
Richmond	4° W
Liberty	3° W
Wytheville	1° W

Locality	*Declination*
Washington	
Southern part	22° E
Central part	23° E
Northern part	24° E
West Virginia	
Eastern part	4° W
Central part	3° W
Western extremity	2° W
Wisconsin	
Milwaukee	3° E
Central part	5° E
Eau Claire	6° E
Wyoming	
Fort Laramie	15° E
Rawlins	16° E
Shoshone Reservation	18° E
Yellowstone National Park	19° E

82. Signal troops should always be supplied with the best obtainable maps of the country in which they may be operating. When the maps or sections are large they should be trimmed, folded and numbered both inside and out to correspond with an index and carried in a map case. A protractor should be carried in the map case with the maps.

In using maps the declination of the compass must always be borne in mind and allowed for —in fact, maps are useless unless used with the compass. Ability to read a map is essential in all military operations, but particularly essential to the signalist.

83. A map is a representation on paper *on a reduced scale* of the surface of the ground in the region depicted.

In order to comprehend a map it must be understood (1) that each distance on it is a certain fixed part of the corresponding distance on

the ground—for example, if two places an inch apart on the map are a mile apart on the ground then an inch anywhere on the map corresponds to a mile on the ground. (2) That the directions of points from each other on the map correspond to their actual directions from each other on the ground. (3) One must also understand the *relative* height of mountains and hills, the depths of valleys, direction of streams, steepness of slopes and shapes of features as shown by contour lines and other symbols.

84. Distance on a map is measured by its "scale." If the scale is 1-62,500, as in the case of the well-known U. S. Geological Survey maps, it means that one inch on the map represents 62,500 inches on the ground, which number is the approximate number of inches in a mile; therefore, the scale is roughly one inch to a mile. If the scale is 1-40,000, the scale is approximately 1½ inches to a mile. By laying a rule on the map and ascertaining the number of inches between two points, one can calculate from the scale the number of miles between them. As the inch is the common unit of meas-

ure in the United States by which the eye is accustomed to judge distances on paper, almost all maps are drawn to a scale representing one, two, three or more miles to the inch.

85. To make measurements of distances easier most maps have on them a graphical scale—a line representing a number of miles and at one end fractions of a mile. In using this remember to read from 0, disregarding the portion of the scale representing the fractions of a mile.

86. In order to ascertain directions or courses from a map it is necessary to "orient" it (to orient a map see Par. 78).

A map may be oriented roughly without a compass as follows:

Find on the map the place where you stand and also some convenient object shown on it, such as a mountain peak. Lay a ruler or other straight object on these points and revolve the map until the distant object is sighted. All the lines on the map are now parallel with the lines they represent on the ground.

87. To find one's place, when unknown, on a map, orient the map. Select a distant object

which is shown on it, lay a ruler or something similar alongside the plotted position of the object, sight the ruler toward the distant object and draw a line along its edge on the map. Select a second distant object nearly at right angles with the first, sight at it over its plotted position on the map and draw a line as before. The intersection of the lines on the map will show your position.

88. Elevations on a map are indicated by irregular curved lines called contours. A contour line can be most easily understood if it is regarded as a water line. Suppose the water level of a large lake rises 30 feet. It will overflow surrounding lowland, extend into nearby ravines and gorges and lap the foot of surrounding knolls or hills. Viewed from a balloon this water line would appear to be very tortuous and irregular, but it would represent *the shape of the ground at that level.* Now suppose the water to rise 30 feet more. The new water line would extend still farther back over the lowland and into the ravines and gorges, but on the steep

knolls, when viewed from above, its position would not appear much different.

89. From this illustration several important points with respect to contours in map reading become apparent, viz.: (1) all points of a contour have the same elevation above the plane of reference (usually mean sea level). (2) That where the successive contours are wide apart the slope is gradual, but where they are close together it is steep. (3) Where a ridge juts out the contours will be convex, whereas in a ravine they will be concave, curving inward toward its head. Contours always head upstream and thus show at once the direction of flow of water.

The distance between these imaginary water lines or contours is called the Vertical Interval (V. I.). This is simply the vertical distance between contours, as in the illustration 30 feet. The horizontal distance between contours is called the Horizontal Equivalent (H. E.). The Vertical Interval is usually indicated on maps and is almost always between 10 feet and 100 feet. Contours usually show here and there in breaks their elevation at 500 feet intervals. The

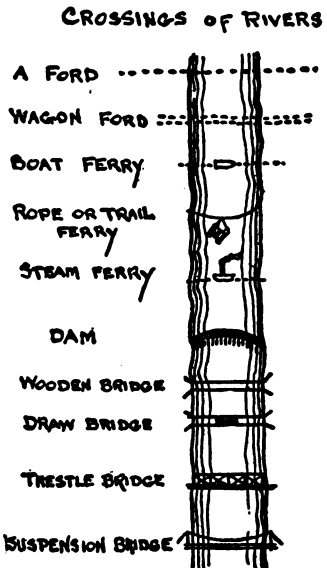
height of a given point can be computed by counting the lines. Sometimes every fifth line is heavier than the intermediary lines. If the contours show no figures giving the elevations, then the existence of water must be one's guide in distinguishing water-sheds and water-courses. Look to the lie and direction of the streams. Their general trend will indicate their lowest levels. Observe where the contour lines project *toward* the streams as this shows the position of water-sheds and spurs; where they *recede* shows the ravines, gorges and valleys.

90. In computing elevations Contour *Intervals* and not contours must be counted. The lowest contour—our original water line in the illustration—must be considered as 0 and not as 1.

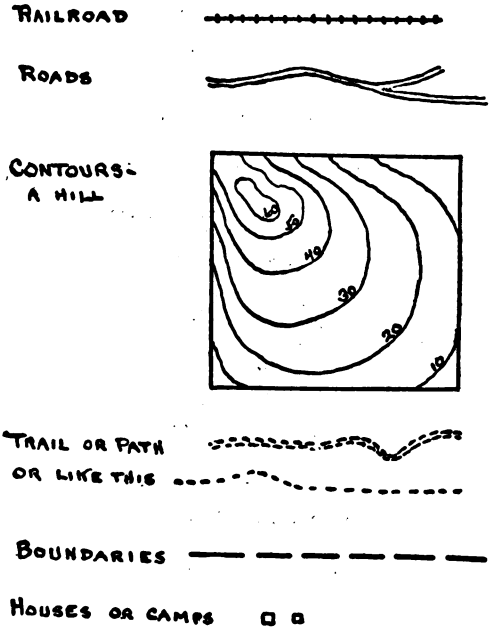
91. In addition to contours certain standard symbols are used to represent features on a map. These symbols are designed to suggest the objects for which they stand. In colored maps water is always blue and contours are brown or red.

92. One of the difficulties in making use of

maps is that they may not be corrected up to date and time may be lost in trying to find roads and other features that have ceased to exist, or to locate on the map new features that have been constructed since it was drawn. For this



reason always obtain the latest possible map of any region in which you are operating.

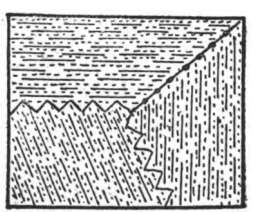


CANAL AND LOCK

SURVEY STATION

TRIANGULATION STATION

CULTIVATED LAND

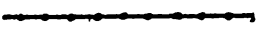


SWAMPS OR MARSH

A GULLY

TELEGRAPH OR
TELEPHONE LINE

WIRE FENCE



FOREST